WHEN ATTENTION DISTRACTION HELPS RULE INDUCTION. AN ENTROPY MODEL

Silvia Rădulescu (Utrecht University), Mridhula Murali (Utrecht University), Sergey Avrutin (Utrecht University), & Frank Wijnen (Utrecht University)
S.Radulescu@uu.nl

What triggers the inductive leap from memorizing items and statistical regularities to inferring abstract rules? We propose an innovative information-theoretic model for both learning statistical regularities and generalizing to new input. Our entropy model predicts that *rule induction is an encoding mechanism triggered by the interaction between input complexity (entropy) and the limited encoding power of the human brain (channel capacity)*.

While traditional cognitive psychology claimed that rule learning relies on encoding linguistic items as abstract categories (Marcus et al, 1999), as opposed to learning statistical regularities between specific items (Safran et al., 1996), recent views converge on the hypothesis that one mechanism – *statistical learning* – underlies both item-bound learning and rule induction (Aslin & Newport, 2012; 2014; Frost & Monaghan, 2016). However, it is still not clear how a single mechanism outputs two qualitatively different forms of encoding – item-bound and category-based generalization, and what triggers the leap from one to the other.

In our model, less *input complexity (entropy)* facilitates finding regularities between specific items, i.e. item-bound generalization, while a higher complexity exceeding *channel capacity* drives category-based generalization.

In two artificial grammar experiments, we exposed adults to a 3-syllable XXY artificial grammar to probe the *effect of input complexity* on rule induction. We designed six experimental conditions with different degrees of input complexity and we used entropy to measure the complexity. Results showed that when input complexity increases, the tendency to infer abstract rules increases gradually (Fig.1)

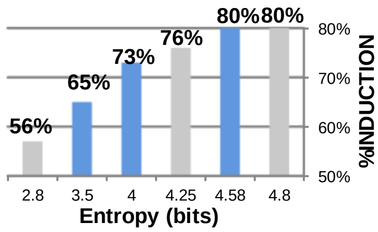

Fig.1.

Next, we aimed to capture the effect of overloading *channel capacity* in the process of rule induction. More specifically, we hypothesized selective attention and working memory modulate channel capacity. Thus, in a new experiment, adults' channel capacity was overloaded by simultaneously playing a stream of digits while exposing them to the lowest entropy grammar (2.8 bits). In one condition, participants had to pay attention to the digits and recall certain digits afterwards. In the second condition, they were asked to ignore the digits. Participants gave grammaticality judgements on: trained XXY strings (correct), new XXY strings (correct), ungrammatical X1X2Y (3 different trained syllables), and ungrammatical new X1X2Y strings. Results showed participants were more likely to generalize (i.e. accept new XXY) when their attention was divided between two active tasks which overloaded their working memory (Dual-task; Fig.2) compared to when no digits were played simultaneously (Single-task; Fig.2), despite the low entropy input. Moreover, distracting participants' attention passively by digits played simultaneously (Distractor; Fig.2) further increased their tendency to generalize (the difference in acceptance of XXY old vs XXY new decreased). In fact, we found the same pattern of responses (generalization) both by overloading participants' channel capacity in this dual task, and by increasing the input entropy from low to medium in the single task. Additionally, overloading participants' channel capacity with the irrelevant inflow of digits yielded the same tendency to generalize exhibited when increasing the input entropy from low to high in a single task. These findings support our main hypothesis that rule induction is triggered by the interaction between input entropy and channel capacity.

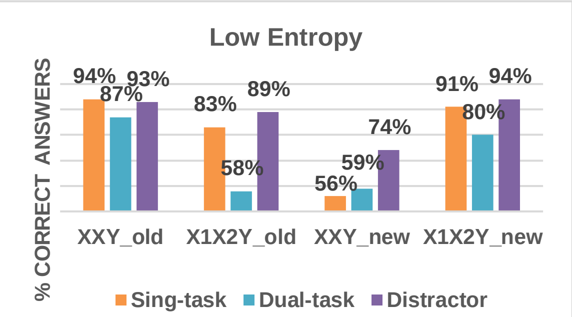

Fig.2